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Landscape approaches to stream fish ecology, mechanistic aspects of habitat selection and behavioral ecology. Introduction and commentary

P. A. Rincón[1], N. F. Hughes[2] and G. D. Grossman[3]
[1]Departamento de Ecología Evolutiva, Museo Nacional de Ciencias Naturales, C.S.I.C., Madrid, Spain, [2]School of Fisheries and Ocean Sciences, University of Alaska, Fairbanks, [3]Daniel B. Warnell School of Forest Resources, University of Georgia, Athens, USA

The Ecology of Stream Fish Symposium (Lobón-Cerviá & Mortensen 1999) was structured as a number sessions destined to showcase the latest developments and prospects for the future in areas of research that, in the opinion of the meeting's Steering Committee and organizers, held particular interest. Convinced of the benefits of research that integrates across fields, the Committee contemplated this division into subtopics as a sort of "necessary evil" imposed by logistics and not without some apprehension about how it may affect the snapshot of current research the Committee hoped the Symposium to offer. The inherent artificiality of this, or any other, rigid scheme was amply confirmed as soon as proposals for presentations started arriving. It was often apparent that slight shifts of emphasis would have allowed the comfortable lodging of the same presentation in different sessions. Fortunately, the Symposium's size did not require running sessions simultaneously, and all participants could attend all talks if they so wished. As a consequence, audiences were always diverse in terms of the research areas represented in them, and this greatly helped to bring out the cross-field aspects of presentations in the subsequent periods for comment and discussion. Thus, common ideas and themes that had attracted the attention of researchers with varied perspectives and primary interests were highlighted, and there was abundant opportunity for the enriching insight provided by views of a certain topic from different angles.

We, as chairpersons of the sessions Landscape Approaches to Stream Fish Ecology (Gary D. Grossman & Pedro A. Rincón), Mechanistic Aspects of Microhabitat Selection (Pedro A. Rincón & Gary D. Grossman) and Behavioral Ecology (Nicholas F. Hughes) had a particularly good opportunity to experience (and enjoy) the situation described above. We were aware in advance of the strong ties among our sessions. If landscape-oriented research is marked by its representation of the environment as a mosaic of patches of different characteristics whose geometry (spatial arrangement and connectivity) can be as relevant as their features, the study of habitat selection by stream fishes can be conceived as inquiry about patch choice at small spatial scales of environmental variation (centimeters to tens of meters, usually). Elucidating the mechanisms producing the observed selection patterns typically involves at least rough attempts to estimate organismal performance (such as prey capture and swimming capacities) and integrate it with environmental conditions into sets of constraints within which the fish are, at least hypothetically, expected to operate in ways ultimately producing fitness maximization. However, this expectation of animals to behave optimally under the specific circumstances they encounter is the same evolutionary logic considered the basis and hallmark of behavioral ecology and that research in that discipline routinely uses to generate testable predictions about animal behavior.

The Symposium turned out to be a good medium for those conceptual links to materialize in a number of more specific research topics and approaches. We take this as a two-fold suggestion: of areas offering exciting opportunities for future research, but also as an indication that such research will be more likely to advance our understanding if it integrates different perspectives. For

example, interest on fish movement proved a true leitmotiv for the whole Symposium. Certainly, it has reasons to attract attention from researchers in different fields. Thus, movement is the vehicle for gene flow, links the local populations that form a metapopulation and allows the outcome of local processes to influence phenomena occurring elsewhere and, potentially, result in patterns observable at larger spatial scales. Realizing this, population ecologists are increasingly in need of information about fish movement (Rieman & Dunham 2000). But moving or staying is also a behavioral, individual choice and, therefore, can be profitably studied within the framework of adaptive decision-making. What we would like to point out is the mechanistic link between both levels of inquiry and that its exploration holds promise. Hughes (2000) offers an example of this by employing a model of optimal habitat selection by individual fish in pools to successfully predict patterns of long-distance movement by Arctic grayling *Thymallus arcticus* in an Alaskan river.

Hughes' (2000) article also featured a relationship between processes within individual pools and patterns at the whole river level. This interaction among factors operating at different spatial scales, their role and relative importances, was the main focus of other papers. Marsh-Matthews & Matthews (2000) reported that broad geographic factors and local terrestrial factors appeared to influence fish assemblage structure more than within-stream aquatic habitat in midwestern streams in the United States. Pusey et al. (2000) found that the strength of within-drainage relationships between habitat features and fish assemblages in northeastern Australia decreased as discharge variability, that changes between drainages, increased. They also detected that regional and drainage-level environmental variation were the major determinants of assemblage composition, apparently dictating the presence or absence of species, while local stream habitat appeared to mainly affect their abundance.

The relationship between environmental variation in space and time and their joint effect on fish assemblages also received attention. High discharges produced by a rainy year after a period of drought and low discharge caused concomitant, significant changes in both habitat and fish assemblages of stream sites within the Guadiana River basin in Portugal. Habitat changes exhibited parallel trends at most sites, and the relationship between local habitat and fish assemblage composition remained similar between the periods of high and low discharge (Godinho et al. 2000).

Consideration of the geographic and temporal scale of demographic processes and life history events was also central in the discussion and synthesis of information that Rieman & Dunham (2000) employ as basis for their evaluation of the widespread applicability of metapopulation models to stream salmonids. In the light of it, they caution that the presence of metapopulation dynamics seems to be more often assumed than actually proven and they warn about the risk for potentially ineffective, or even negative, management decissions based on such assumption.

Several presentations shared a reliance in monitoring and characterizing individual fish. Both the exploration of the mechanisms of habitat selection and the study of fish behavioral decisions are concerned with parameters (performance, fitness) that ultimately are individual attributes. Therefore, it is reasonable to expect that simultaneous information on different traits at the individual level should help our understanding. Accordingly, the efforts of reseachers working in these areas have been increasingly directed towards obtaining and analyzing this kind of data. The articles by Juanes et al. (2000) and Greenberg & Giller (2000) describe methods for individual-based research and illustrate the potential that such studies hold with examples focusing of growth, habitat use and movement of juvenile Atlantic salmon *Salmo salar* in the Connecticut River, United States, and of brown trout *Salmo trutta* in southern Sweden, respectively.

Assumptions about individual performance are often built into modelling exercises or, explicit or implicitly, incorporated into arguments seeking to explain patterns of habitat selection, movement, etc. One such assumption is that foraging efficiency for young, drift-feeding stream fishes in the field is high, comparable to the the 70–100% success they exhibit in laboratory situations. However, McLaughlin et al. (2000) present results from an observational study in natural conditions that challenge such a belief, as they found that recently emerged brook charr *Salvelinus fontinalis* only ingest less than 42% of the prey they initially attack. They argue that such poor capture success is likely to be a significant aspect of the early ecology of young salmonines.

This set of articles provides examples of topics and approaches that are already producing progress in our understanding of the ecology of stream fishes and are likely to continue rewarding future investments of effort in them. No less relevantly, they also demonstrate how, given the nature of ecological questions, integration both across sub-fields of study and across temporal and spatial scales is contributing a very relevant part of our current advance and appears likely to do so to an even larger extent in the future.

Finally, we want to express our gratitude to all who contributed to the publication of this collection of articles: the different institutions who provided financial support for the Symposium, the personnel involved in various ways in the running of sessions at Luarca, authors and reviewers of articles, the Symposium's Steering and Organizing Committees and, particularly, Dr. Javier Lobón-Cerviá, whose brainchild the Symposium was and to whose efforts as Convener it largely owes its existence.

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